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AUTHOR(S):

Lee, In Min

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THE DISTRIBUTION OF THE MYELINATED NERVES IN THE COLON OF THE DOG

by

In Min Lee

From the 2nd Surgical Division, Kyoto University Medical School
(Director: Prof. Dr. Yasumasa Aoyagi)

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I. INTRODUCTION

Very few reports have been made on the histological study of distribution of the myelinated nerves in the wall of the colon. Recently the author has demonstrated that there are sensory nerves in the colon which are myelinated nearly to their termations in peripheral layers.

The author, then, tried further to study the distribution of sensory nerves in the colon by means of counting the number of these myelinated nerve fibers in various parts of the colon; in the ascending, transverse, and descending colon. His research was started with the classification of the myelinated nerves into 3 categories of size, i. e., large, medium, and small. Then their general distribution in the wall of the colon was studied, leading to a comparative study on their distribution in the ascending, transverse, and descending colon.

II. MATERIALS AND METHODS

Three dogs weighing about 10kg each were employed. Strips (1.5 × 1.5cm) were taken from the middle portion of the ascending, transverse, and descending colon; they were made into sections 40μ thick from the muscular layer to the mucous layer; they were stained by Ehrlich's acid hematoxyline method and the numbers of the myelinated nerves contained there in were counted. In principle the author has divided the myelinated nerve fibers into 3 groups according to Saegusa' s and Fukuyama' s classifications:

1) Group of small sized fibers; 1μ to 3μ in diameter, and with a very thin myelin sheath. They are characterized by shortness of Ranvier' s internodal length (90~130μ) and paucity of Schmidt-Lantermann's clefts (mostly absent).

2) Group of medium sized fibers; 3μ to 5μ in diameter, with moderately thick medulla which possess a small number of Schmidt-Lantermann's clefts in each internodal segment.

3) Group of large sized fibers; more than 5μ in diameter, with the very thick medulla which possess a very large number of Schmidt-Lantermann's clefts in each internodal segment.

The result is shown in the table 1, 2.

III. THE GENERAL DISTRIBUTION OF THE MYELINATED NERVES IN THE COLON OF THE DOG

Throughout all cases, a considerable number of the myelinated nerves was found, although not in a uniform distribution, in every part of the colon. (Table 1.) These myelinated nerves, contained in a non-myelinated nerve bundle, enter AUERBACH' s plexus. Some of them pass through the muscular layer eventually reaching the submucous layer; a few of them were found not only in the lamina muscularis mucosae and lamina propria mucosae, but also between the crypts of the intestine. The myelinated nerves in the submucous layers are decreased to 1/4~1/9 in number compared with those in AUERBACH' s plexus and the muscular layers. (Table 1.) This may be due to the myelinated parasympathetic nerves, which changing their neurons at AUERBACH's plexus, become non-myelinated in the peripheral layers. Various sized myelinated fibers were found in all layers of the colon. In AUERBACH's

Table 1. Distribution of the myelinated nerve fibers in the colons of dogs (in 1.5 cm ×1.5 cm ×40μ ×40 sections)

	Ascending colon		Transverse colon		Descending colon	
Layer	Auerbach's plexus Muscular	Submucous Mucous	Auerbach's plexus Muscular	Submucous Mucous	Auerbach's plexus Muscular	Submucous Mucous
Case No. 1	125	23	529	48	1.674	346
No. 2	163	18	612	32	1.552	536
No. 3	168	23	319	78	921	163
Mean Number	152	21	487	53	1.382	348
Ratio	1	1/7	1	1/9	1	1/4

Table 2. Distribution of the myelinated nerve fibers in the submucous and mucous layers of the colons of dogs (in 1.5 cm ×1.5cm ×40μ ×40 sections)

		Ascending colon			Transverse colon			Descending colon		
Layer		Submucous	Mucous	Total	Submucous	Mucous	Total	Submucous	Mucous	Total
	Large	0	0	0	0	0	0	1	0	1
Case	Medium	14	1	15	21	2	23	221	8	229
No.1	Small	8	0	8	24	1	25	113	3	116
	Total	22	1	23	45	3	48	335	11	346
	Large	0	0	0	0	0	0	2	0	2
Case	Medium	7	0	7	14	1	15	307	15	322
No.2	Small	11	0	11	15	2	17	206	6	212
	Total	18	0	18	29	3	32	515	21	536
	Large	0	0	0	0	0	0	0	0	0
Case	Medium	15	0	15	44	1	45	94	9	103
No.3	Small	8	0	8	33	0	33	57	3	60
	Total	23	0	23	77	1	78	151	12	163
	Large	0	0	0	0	0	0	1	0	1
Mean	Medium	12	0.33	12.33	26.33	1.33	27.66	207.33	8.67	216
Number	Small	9	0	9	24	1	25	125.33	6	131.33
	Total	21	0.33	21.33	50.33	2.33	52.66	333.66	14.66	348.33

plexus, far the most part the myelinated fibers was small sized, while in the submucous layer the number of them was not greater than that of medium sized myelinated fibers. This suggests that those small sized myelinated nerves change their neurons at AUERBACH' s plexus and lose their myelin sheaths in the peripheral layers. From the above mentioned facts, at least a part of the small sized myelinated nerves must be preganglionic fibers of parasympathetic nerves. Here, the medium sized myelinated fibers in the colon are mostly 3 3μ to 4μ in diameter.

The author found that the myelinated fibers which run through the submucous layer to the mucous layer did not change their neurons at the intramural plexus. He made a special study of these myelinated fibers, because they are easily identified as sensory nerves. The result of the experiment thus tried is shown in Table 2. Generally they are very small in number.

IV. COMPARATIVE STUDY ON THE NUMBER OF THE MYELINATED NERVES DISTRIBUTED IN THE ASCENDING, TRANSVERSE, AND DESCENDING COLON OF THE DOG

The number of the myelinated nerves in all layers of 40 sections (1.5×1.5cm, 40μ thick) was 173 in the ascending colon, 540 in the transversecolon, and 1730 in the descending colon, a ratio of 1 : 3 : 10. (Table 1)

The number of the myelinated fibers in AUERBACH' S plexuses in 40 sections was 152 in the ascending, 487 in the transverse, and 1,382 in the descending colon, a ratio of 1 ; 3 : 9. (Table 1)

The number of the myelinated nerves in the submucous and mucous layers in the 40 sections was 21 in the ascending, 53 in the transverse, and 348 in the descending colon, a ratio of 1 : 2.5 : 16.5. (Table 1)

The myelinated nerves in the mucous layer of the colon were always very small in number, and those of the ascending, transverse, and descending colon showed a ratio of 1 : 7 : 44. (Table 2)

Generally speaking, the number in each layer is greatly increased in the descending colon.

The myelinated nerves in the submucous and mucous layer consisted of 42% small, 58% medium, and 0% large sized fibers in the ascending colon ; and 47% small, 53% medium, 0% large sized fibers in the transverse colon ; and 37.7% small, 62% medium, 0. 3% large sized fibers in the descending colon.

The number of the small sized fibers in the submucous and mucous layers in the 40 sections was 9 in the ascending colon, 25 in the transverse colon, and 131 in the descending colon, a ratio of 1 : 2.8 : 14.6. (Table 2) The number of the medium sized fibers (mostly 3.3~4μ in diameter) in the submucous and mucous layers in the 40 sections was 12 in the ascending colon, 28 in the transverse colon, and 216 in the descending colon, a ratio of 1 : 2. 3 : 18. (Table 2)

The small and medium sized fibers, thus, showed a marked increase in number in the descending colon.

Large and maximum sized fibers (more than 7μ in diameter) were found nei-

ther in the ascending colon nor in the transverse colon. However, they were found, although small in number, in AUERBACH' s plexus, the muscular layer and the submucous layer of the descending colon.

V. DISCUSSION

The bundle of the myelinated nerves which run through the longitudinal muscular layer make up AUERBACH's plexus together with the nerve cells between the longitudinal and circular muscular layer. Many of the various sized myelinated nerves are found in AUERBACH's plexus, but only 1/4～1/9 of that number reach the submucous layer through the circular muscular layer with their myelin sheaths. Some of them make up Meissner's plexus together with the nerve cells in the submucous layer. The decreased number of myelinated fibers in the submucous layer were mostly small sized. According to GASKEL and DRESEL, preganglionic fibers of the parasympathetic nerves end at the nerve cells in the intramural plexus. The above mentioned facts, which the author found in the wall of the colon, show that the extrinsic parasympathetic nerves are small sized fibers, and most of them terminate at the nerve cells in AUERBACH' S plexus of the colon, while a small number of them terminate at the nerve cells in MEISSNER'S plexus.

ISHIKAWA and SEKIGAWA also reported that all of the myelinated fibers of the extrinsic autonomic nerves end at the nerve cells in the intramural plexus, so that no myelinated fiber is found in the muscular and mucous layer. But the author found some myelinated fibers which entered the mucous membrane from the submucous layer passed through MEISSNER'S plexus and some did not. Therefore, these myelinated fibers must be non-autonomic nerves. STÖHR maintains that the autonomic nerves in the peripheral layer make the "terminalreticulum". The author confirmed that the myelinated nerves in mucous layer were degenerated following the posterior rhizotomy in his study on the sensory nerves of the colon. Therefore, the myelinated nerves in mucous layer must be sensory in nature. However, the myelinated fibers were found to be much fewer in the mucous layer than in the submucous layer. This fact suggests that most of the myelinated fibers in the submucous layer end at the nerve cells in MEISSNER'S plexus, and the sensory nerves are small in number, or most of the sensory nerves may enter the mucous layer after losing their myelin sheaths.

The myelinated fibers in AUERBACH'S plexus of the ascending and transverse colon are small in number, and in the descending colon they are numerous, showing a raitio of 1 : 3 : 9. The descending colon shows special continuous contrac- tions for defecation. The great number of these small sized myelinated fibers in the descending colon may well explain this functional characteristics.

The author considers the strength of the peristaltic waves or continuous contraction must be proportional to the number of the myelinated nerves in AUERBACH'S plexus. Only a small number of the myelinated fibers, which are considered the parasympathetic nerves, are found in the ascending and transverse colon. Therefore, the author considers that the sympathetic nerve innervation is more dominant

than the parasympathetic in the ascending and transverse colon. According to SEKIGAWA, the sympathetic nerves accelerated absorption. From this point of view the active absorption must be done in these parts of the colon.

In the mucous membrane of the descending colon, myelinated fibers were found in a considerable number, even between the intestinal glands. The medium sized myelinated nerves are small in number in the submucous layer of the ascending and transverse colon, but they greatly increase in number in the descending colon. Large sized fibers are not found in the ascending nor in the transverse colon, whereas there is a considerable number in the descending colon. The myelinated nerves in the mucous layer must be sensory in nature. The medium and large sized myelinated nerves are referred to as sensory nerves by ALLEN, WINDLE, HAMABE, WATANABE, HEINBECKER and TAZAKI. ISHIKAWA reported that the sensitivity to pain in the visceral organs were directly proportional to the number of medium and large sized myelinated nerves. Therefore, the author's findings suggest the same mode of sensory innervation in the ascending and transverse colon, but it is quite different in the descending colon. From the physiological point of view, the deeper we enter into the colon, the more sensitive the sensory function. The descending colon is actually distributed with a larg enumber of sensory nerves, which is confirmed by these findings. The nature of the sensitivity in the descending colon is characteristic in the stimulation to defecate. Therefore, the increased number of the myelinated fibers in the mucous membrane of the descending colon shows, that these are sacral parasympathetic sensory nerves.

VI. CONCLUSION

1) Myelinated nerves are found in large number in every part of the colon of the dog. Most of them are distributed in AUERBACH's plexus.

2) A small number of the myelinated nerves are found in the submucous layer, the number of which is about 1/4～1/9 of myelinated fibers found in AUERBACH's plexus. Therfore, the author considers that most myelinated nerves in the wall of the colon end at the nerve cells in AUERBACH's plexus, and a small number of them ends at the nerve cells in MEISSNER's plexus.

3) Generally a much smaller number of the myelinated nerves are found in the mucous membrane of the colon, but the number increases in the descending colon compared with those in the ascending and transverse colon.

4) The percentage and its ratio in the number of small, medium and large sized myelinated fibers in the submucous and mucous layer are 42 : 58 : 0 in the ascending colon, 47 : 53 : 0 in the transverse colon, and 37. 7 : 62 : 0. 3 in the descending colon. In AUERBACH's plexus in these parts of the colon, far the most part the myelinated fibers is small in size, while their number is markedly decreased in the submucous and the mucous layer. There are not more than the number of medium sized fibers.

5) The number of the myelinated nerves in AUERBACH's plexus of the ascending, the transverse, and the descending colon is in the ratio of 1 : 3 : 9 ; i. e. they increase

greatly in the descending colon.

6) The medium and the large sized myelinated nerves which are believed by the author to be sensory nerves are small in number in the submucous and mucous layers of the ascending and the transverse colon, but they increase greatly in the descending colon, with a ratio of 1 : 2. 3 : 18. The large sized myelinated nerves are found only in the descending colon. Therefore, the descending colon is distributed with a large number of sensory nerves, which may play a role in receiving defecatory stimulation.

7) The findings on the distribution of the myelinated nerve fibers in the colon show that the mode of nerve innervation in the ascending and in the transverse colon is similar, yet very different from that in the descending colon.

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（和文抄録）

犬の上行結腸，横行結腸及び下行結腸に於ける有髄神経線維の分布状態について

京都大学医学部外科学教室第2講座（青柳安誠 教授 指導）
李　仁敏

Ehrlich 氏神経髄鞘染色法を用いて，犬の上行結腸，横行結腸及び下行結腸に於ける有髄神経の分布状態を研究し，次の結果を得た．

1) 犬の上行，横行及び下行結腸には多数の有髄神経線維が見出されるが，その大部分は各結腸の Auerbach 氏神経叢に分布している．

2) 粘膜下層には有髄神経線維は少く，同じ標本の Auerbach 氏神経叢に分布する有髄神経線維数の1/5乃至1/4しか認められない．従て之等の結腸の大部分の有髄神経線維は Auerbach 氏神経叢の神経節細胞に終り，少数のものが Meissner 氏神経叢の神経節細胞に終るものと考えられる．

3) 上行結腸及び横行結腸の粘膜層に於ては甚だ少数の有髄神経線維が見出されるが，下行結腸の粘膜層ではその数が増加し，かなりの数としてみとめられる．

4) 上行結腸の粘膜下層と粘膜層に於ける小径，中径，大径の有髄神経線維の数の比率は，42%(小径)：58%(中径)：0%(大径)，横行結腸では47%(小径)：53%(中径)：0%(大径)，下行結腸では 37.7%(小径)：62%(中径)：0.3%(大径)である．以上の如く Auerbach 氏神経叢で大部分を占めていた小径が粘膜下層，粘膜層では激減し，中径よりもむしろ稍々少くなつている．こゝに示された中径の有髄神経線維は大部分3.3μ乃至4.0μの太さのものである．

5) 上行，横行及び下行結腸の Auerbach 氏神経叢の有髄神経線維の数の比率は1：3：9であつて，下行結腸に於て激増している．

6) 知覚神経と信ぜられる中径，大径の有髄神経線維は上行結腸及び横行結腸の粘膜下層及び粘膜層には少数であるが，下行結腸に於てはその数が急激に増加し，1：2.3　18の比率を示し，特に大径の有髄神経線維は下行結腸にのみ見出される．従て之は下行結腸には多数の知覚神経が分布していることを示すもので，特に之等の知覚神経は排便を促す刺戟を感受する役目を演ずるものと考えられる．

7) 上記の所見は上行結腸と横行結腸に於ける神経支配の形式は同一であるが，下行結腸に於ける神経支配の形式は之等上部の結腸とは甚だ異ることを示しているものである．

The Pathogenesis of Acute and Chronic Pankreatitis

S. R. Powers, H. H. Brown and A. Stein

Ann. Surg., **142**; 690, 1955.

実験的に膵臓炎を起した犬に就て，生化学的，病理学的研究を行い，トリプシンの急性膵臓炎の病因としての役割を観察し，次の結論を得た．

即ち急性膵臓炎は膵管閉塞による膵臓間質液内のトリプシノーゲンの増加及びこのトリプシノーゲンの活性化によつて起る．

尚膵総胆管吻合術の術式竝に血清トリプシン及びトリプシノーゲンの定量法に就ても言及す．

（長瀬正夫抄訳）